Nordic TSO response to NordREG's Letter to Nordic CCR TSOs Concerning Flow-Based implementation and ID ATCE

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1.1 Introduction

This report is a Nordic TSO response to a Nordic NRA request on the functioning of ATCE, received on July 1st. The response is structured in two documents, where the two questions related to ATCE functioning are placed in the Annex 1 and 2.

1.2 Response to concerns on ID capacities

NRAs raised two concerns:

1. **Lock-in situations**: Lock-in situations and possible critical situations where the total import- or export trading space on intraday does not allow for the need of net import or export to the bidding zone are issues that concern the Nordic NRAs. To understand the consequences for the market, the TSOs should investigate these situations thoroughly and, if deemed necessary, suggest the possible measures that could be introduced and their effects to the day-ahead and intraday market.
2. **Arbitrage possibilities**: The combination of including CNECs with small PTDFs in the day-ahead capacity calculation and relaxations in ATCE creates new possibilities for arbitrage. On the other hand, not relaxing the ATC domain would further reduce the ID capacities made available to the market. The Nordic NRAs acknowledge that the transitional solution with use of ATCE in the intraday capacity calculation entails a need to strike a balance between operational security and sufficient ID capacities. The TSOs should therefore thoroughly investigate the necessary level of relaxations in ATCE and minimize the consequences of these new arbitrage opportunities.

As a point of departure, Nordic TSOs would like to stress that lock-in situations are an inherent result of applying an ATCE approach, thus it is not possible to avoid. What can be done, is to apply relaxation parameters to relieve such situations, yet one has to understand that the relaxation proposed is based on "virtual" capacity. Relaxation is done by adding 10 MW of RAM to all CNECs and by leaving out zone-to-zone PTDFs below 2% (yet maintaining the other z2z PTDFs for the particular CNEC). Relaxation is a remedy but will not solve the root cause and comes at the "cost" of possible arbitrage on "virtual" trade capacities between bidding zones. As Nordic TSOs understand, the NRAs are concerned about the risk of negative impact on operational security and economic efficiency of potential arbitrage. Nordic TSOs understand the operational security risk as one or more CNEs that will be overloaded, and understand the economic efficiency risk as a lack of merit order dispatch (obtained in the first round of market operation in the DA market). The risk of these concerns to materialize is due to arbitrage, as market players may take advantage of BZ price differences and the supply of virtual ID capacity.

Before addressing these concerns, Nordic TSOs would like to make clear that arbitrage is a natural strategy and is a *simultaneous purchase and sale of the same or similar asset in different markets in order to profit from tiny differences in the asset's listed price. It exploits short-lived variations in the price of*

identical or similar financial instruments in different markets or in different forms. Arbitrage exists as a result of market inefficiencies, and it both exploits those inefficiencies and resolves them.[1]

Arbitrage is a financial strategy that is typically free of (market) risk, and that is where arbitrage differs from speculation, which is a financial strategy where the trader takes a financial position based on expected movements in market prices, and thus involves a risk.

In most situations exploiting potentials of arbitrage can be regarded as being positive for the market efficiency, as arbitrage provides a mechanism to ensure that prices do not deviate substantially from fair value for long periods of time. Due to the potential of (risk free) profit, arbitrage will (naturally) attract market players and bring down price differences. So, just to be clear, arbitrage is not a problem in itself, but in the actual situation of "virtual" ID capacity in the electricity market this might in theory cause some downsides in terms of operational security and economic efficiency in the following way:

- Operational security: The relaxation will provide virtual capacity, thus a risk of overloads of CNEs as market players will take advantage of the arbitrage opportunity.
- Economic efficiency: The relaxation of capacity limitations may alter the welfare optimal market equilibrium obtained in the DA market, thus distorting the merit order dispatch.

However, the Nordic TSOs are not highly concerned that those downsides materialize, partly due to the fact that the order of magnitude for relaxation is within the standard uncertainties from the CC process, partly as they are not convinced that arbitrage actually will take place. Firstly, given the uncertainties within the CC process (assumptions on the CGM, GSK, and more), we expect that the relaxation can introduce potential "overloads" that are within the region of those uncertainties already present in the CC process. Secondly, the introduction of Intraday Auctions (IDAs) may (more or less) remove the potential for profit based on arbitrage and turn this profit into ID congestion rent for TSOs. Why? At the outset of the gate opening of the first IDA, relaxation may cause a situation of XX MW idle capacity and a DA price spread that will attract market players for the capacity auction. If it is assumed that competition is working properly, the bid prices for capacity will reflect the price spread, maybe less, but not more. Given the fact that market players then pay the auction price, reflecting the initial price spread, the profit from arbitrage is turned into congestion rent, thus decreasing the incentive for arbitrage in the first place. There is less incentive for a market player to consider arbitrage if it does not turn out as (significantly) increased profit. On the other hand, some arbitrage can be expected to take place as idle ID capacity and a price spread will not be "left untouched" by market players. But the introduction of IDAs will support the application of relaxation parameters, dampening the downsides.

In case arbitrage will materialize, will this in the end boil down to the above-mentioned down sides? Nordic TSO are in general not in favor of providing RAM to the market that does not reflect the physical realities (i.e. the provision of virtual capacity). However, due to the order of magnitude of the relaxation

[1] https://www.investopedia.com/terms/a/arbitrage.asp

parameters (being way below the potential operational consequences of the 70%-rule), Nordic TSOs assess the consequences of this to be minor, where operational impact can be handled with the general management of uncertainty and imbalances. Yet, we cannot rule out that it might have an impact on economic efficiency.

Content of annexes

For lock-in situations, TSOs answer this request by going through the different relaxation options analyzed by the TSOs to show how different relaxation parameters affect the balance between operational secure capacity, sufficient ID-capacity, and number of lock-in situations. The relaxation of parameters in the ATCE implies that some additional capacity will be released to the intraday market, that was not available for the day-ahead market. The reason for these relaxations, on both PTDFs and RAM is, as the NRAs state, to find the right balance between operational security and sufficient intraday capacities. Our analysis shows (see table 1 in the annex 1) that a PTDF relaxation of 2% strikes a balance between trading possibilities and risk of overloads; increasing the PTDF relaxation from 1 % to 2% increases trading possibilities, mostly for NO4, whereas a further increase to 3% does not provide more possibilities.

For arbitrage possibilities, TSOs answer this request by going through the case of arbitrage and applied relaxation parameters. Based on data for mid-2023 to mid-2024 the assessment on the percentage of time where arbitrage possibilities materialize (meaning both a positive price-spread and positive ATC) shows that the possibilities vary between the borders and may arise around 5-15 % of the time for most of the borders. NO2>DK1, NO5>NO2, SE2>SE1 SE3>SE2, SE4>SE3, and SE1-FI have arbitrage possibilities for 25 % of the time or more.

For a detailed explanation about lock-ins and arbitrage possibilities we refer to the Annexes.

1.3 Response on time period for the use of ATCE transitional solution.

The third concern raised by NRA is on the **time period for the use of ATCE transitional solution.**

The Nordic NRAs observe a reduction of capacities in intraday. The solution that will be implemented at go-live, where the calculation will be moving from flow-based capacity calculation in day-ahead to ATCE in intraday, does not allow for optimal utilization of the intraday capacity and is a transitional solution only. The TSOs should therefore present the time plan for introducing flow-based capacity calculation in intraday

Before going into the response to this request, TSOs would like to clarify that a reduction in ID capacities is not an impact of ATCE only. Flow based in the DA provides a better utilization of the grid, thus less capacity stays idle from the DA market operation, hence less is available for ID. Yet, TSOs acknowledge that ATCE provides a smaller domain in ID than a future implementation of Flow Based is expected to do.

The ATCE solution in the ID market is a transitional solution given the fact that the mechanism for continuous ID trade facilitation, XBID, is not ready for flow-based by the time of flow-based go-live in the DA market. Currently the legal requirements are the following:

- CACM, Article 20(1): "*For the day-ahead market time-frame and intraday market time-frame the approach used in the common capacity calculation methodologies shall be a flow-based approach (...)"*
- Nordic CCM, article 20.1: "*Until the single intraday coupling in accordance with Article 51 of the CACM Regulation is able to support the allocation of cross-zonal capacities based on FB parameters, the CCC shall transform the final FB parameters as referred to in Article 19 into available transmission capacity ('ATC') values (…)*". There is no hard deadline for flow-based implementation in ID, yet conditional on when the intraday allocation mechanism can support flow based.
- Nordic CCM, article 26.2 "*The TSOs shall implement the capacity calculation methodology of the Second Amendment on all bidding zone borders within the Nordic CCR after ... the relevant requirements set in algorithm submitted in accordance with Article 37(5), ... are implemented in the Nordic CCR*." Thus, the implementation of FB ID is also dependent on implementation of FB ID market coupling (XBID), where no implementation timeline has been set yet.
- The Algorithm methodology in accordance with CACM Article 37, which was adopted by ACER Decision 04/2020, includes an annex outlining requirements for the continuous trading matching algorithm and the intraday auction algorithm. These requirements state August 2023 as a deadline for when the intraday market algorithms should have the ability to handle flow-based parameters. This requirement has not been met.

When it comes to implementation of flow-based on the ID market, one must distinguish between *capacity allocation* and *capacity calculation*. Capacity calculation is a regional responsibility performed by the Nordic RCC while the capacity allocation is a European issue.

Capacity allocation is a two-step process containing Intraday Auctions (IDA), applying Euphemia, and continuous trade, taking place at XBID. So far, the TSOs and NEMOs have not been able to implement flow-based in XBID due to inherent features of the platform. The issue with implementing FB in the continuous intraday market is primarily twofold. First, the performance of the routing algorithm in the XBID system is very poor because, in path calculations, flow-based segments take significantly more computing power than ATC-based segments. Secondly, and more critical from a conceptual point of view, is the issue of algorithmic crossed order books, which results in perfectly viable matches of any volume that may be left unfound, and thus unexecuted, by the matching algorithm. The issue arises because, in a hybrid (ATC/FB) topology, the state of the non-visited part of the graph may change during the execution of the matching algorithm, if this part belongs to a flow-based region. In other words, if the same flow-based region is visited twice on the same path, we see the issue of crossed order books.

This issue is unacceptable, as it would not allow the matching algorithm to maximize socioeconomic welfare. There is no indication when continuous intraday trade will be ready for the flow-based approach. Several solutions are currently being investigated by the TSOs and the NEMOs.

As an intermediate step towards a full flow-based capacity allocation in both the auctions and in continuous trade, the European TSOs and NEMOs are currently investigating a hybrid solution. This entails intraday auctions based on flow-based domains, and continuous trade based on ATC-domains. This hybrid solution includes a process of ATC extraction after each IDA to translate capacities from FB-domains in IDAs to ATC-based domains in continuous trading. Planning and process design are expected to take until early 2025, whilst the timing of implementation is still not planned in detail.

Capacity calculation, which is a regional issue, consists of several building blocks:

- FB calculation: Considering forced outages, left-over capacity from DA will be calculated and offered for ID.
- CGM creation: At the start, D-2 CGMs is applied. Update of ID domains beyond the DA left-over capacity requires further development of D-1 and ID CGMs. This will be done cf. article 21 in the CCM.
- Internal and external parallel run, when switching the input data to the allocation platform from NTC to FB.

Currently there is no formal ID capacity calculation implementation project in the Nordics, yet TSOs and Nordic RCC are about to start the planning process.

ANNEX 1: Lock-in situations and relaxation

Background (the issue)

The NRA has asked the TSO the following question:

"Lock-in situations and possible critical situations where the total import- or export trading space on intraday does not allow for the need of net import or export to the bidding zone are issues that concerns the Nordic NRAs. To understand the consequences for the market, the ***TSOs should investigate these situations thoroughly and, if deemed necessary, suggest the possible measures that could be introduced and their effects to the day-ahead and intraday market****"* The NRA also request the TSOs ***"… to include operational aspects and results from the intraday auctions in their analyses".*** Later the NRAs also ask that the "***TSOs should therefore thoroughly investigate the necessary level of relaxations in ATCE..."*** which has great impact on ATCE-results and eventual lock-in situations.

This Annex answers this request by going through the different relaxation options analyzed by the TSOs, to show how different relaxation parameters affect the balance between operational secure capacity, sufficient ID-capacity and number of lock-in situations. The relaxation of parameters in the ATCE implies that some additional capacity will be released to the intraday market, that was not available for the day-ahead market. The reason for these relaxations, on both PTDFs and RAM, is as the NRAs state, to find the right balance between operational security and sufficient intraday capacities. Some relaxation is also required to provide enough space for the solver to mathematically find a solution. The chosen relaxations parameters are:

- **PTDF-relaxation: 2 %**

The zone-to-zone PTDFs with a 2 % or lower impact on any limitation are removed (rounded down to zero), yet the individual CNE will remain including zone-to-zone PTDFs above 2%. The reason of the relaxation is to improve the ID market trading possibility at the ID market gate opening, considering the manageable operational risks associated with the introduced relaxation. Providing a similar relaxation to the day-ahead market would allow for more capacity in the day-ahead market, but it is likely that all that capacity would be utilized in day-ahead. Consequently, the intraday capacities would either remain quite small, or the TSOs would have to further relax the PTDFs in ID, which would not be operationally secure.

- **RAM-relaxation: 10 MW**

The remaining available margin (RAM) on all CNEs, CNECs and PTCs are increased with 10 MW between the FBDA and ATCE ID timeframe. This is to take into account that not all loading flows on any particular constraint are deemed likely to take place at the same time. Hence, there exists room for additional margins for the CNECs / CNEs / PTCs that could be allocated to the ID-timeframe. The FB DA-result gives the operator new information about the actual flows and directions, meaning that the uncertainties of

the expected market flows has been reduced. The reason for a fixed 10 MW increase, instead of a certain percentage of the Fmax value, is to make sure that the actual over-allocation stays below 10 MW in the case of unfavourable flows in every loading direction. An overload of 10 MW is deemed operational feasible, with the standard operational measures, by the TSOs.

Relaxation and lock-in assessment

In this section we illustrate the impact of different relaxation levels on the number of lock-in situations[2]. We do that by employing the boxplot, which is illustrating the spread of data. The center line inside the box represents the median value, and the box itself contains 50% of the data points. The outer lines represent the remaining data, but if some data points are far from the first or third quartile, they are represented as outliers (black circles). Thus, larger spreads of data are represented by longer boxes and longer outer lines. The following figures show boxplots of intraday capacities using ATCE for different PTDF-relaxation values.

Please be advised that the purpose of the graphs/analyses in this section is to make a comparison among 3 different relaxation settings.

[2] The simulation duration is from week 26, 2023 to week 12, 2024 inclusive.

PTDF-relaxation 0 %

Figure 1 and Figure 2 show that when using the 0 % PTDF relaxation, the given intraday capacity is very limited especially at NO3, NO4 and NO5 bidding zones. As the figure shows, a median of 130 and 403 MW is available for NO3 and NO4 in export direction respectively. In addition to that, the given export capacity for SE1 and SE2 is very low, which is illustrated by the median value of 640 and 706 MW respectively.

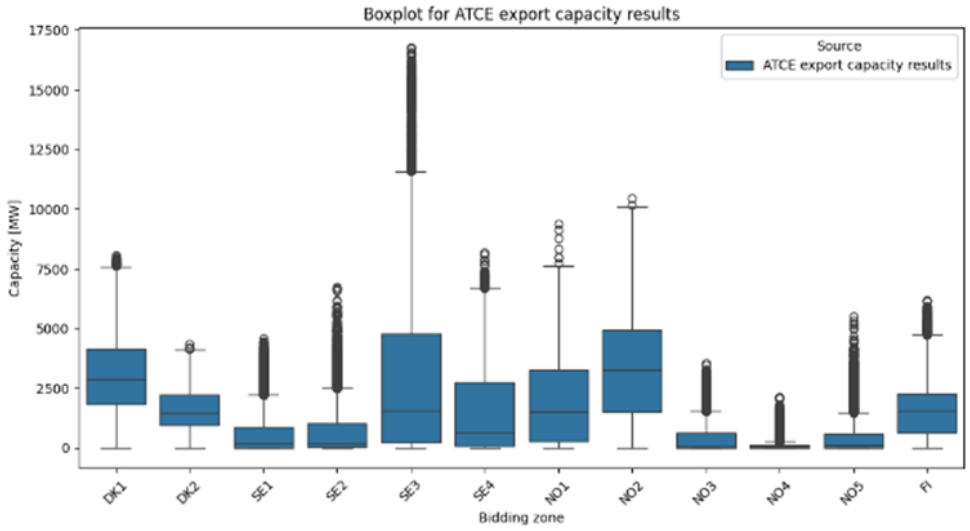

Figure 1 Boxplot for ATCE export capacity results using the PTDF 0 % relaxation

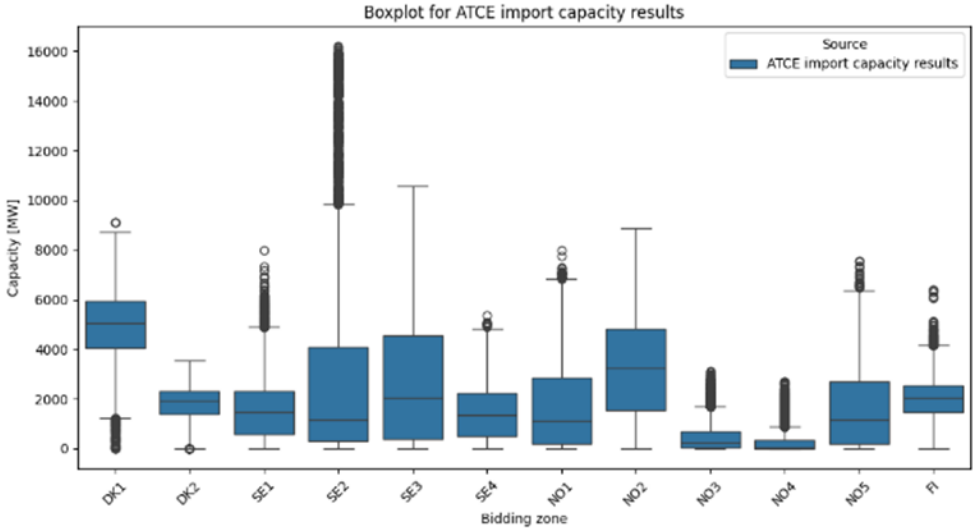

Figure 2 Boxplot for ATCE import capacity results using the PTDF 0 % relaxation

PTDF-relaxation 1 %

Figure 3 and Figure 4 show the given export and import intraday capacities using the 1 % PTDF relaxation. The intraday capacities are slightly higher than with 0 % PTDF relaxation but still very limited, especially in NO3 and NO4. Here, the export capacity is increased to a median value of 206 and 476 MW respectively. In addition to that, NO5, SE1 and SE2 have relatively limited export capacities.

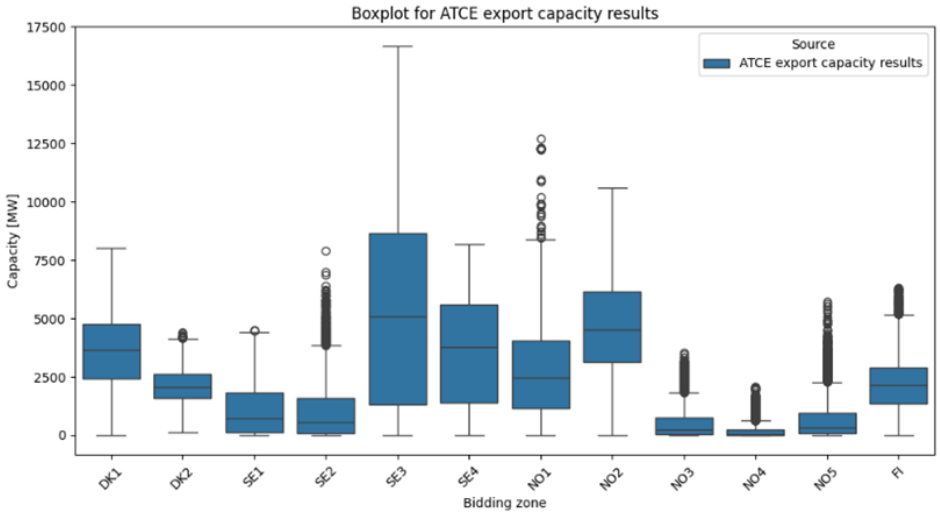

Figure 3 Boxplot for ATCE export capacity results using the PTDF 1 % relaxation

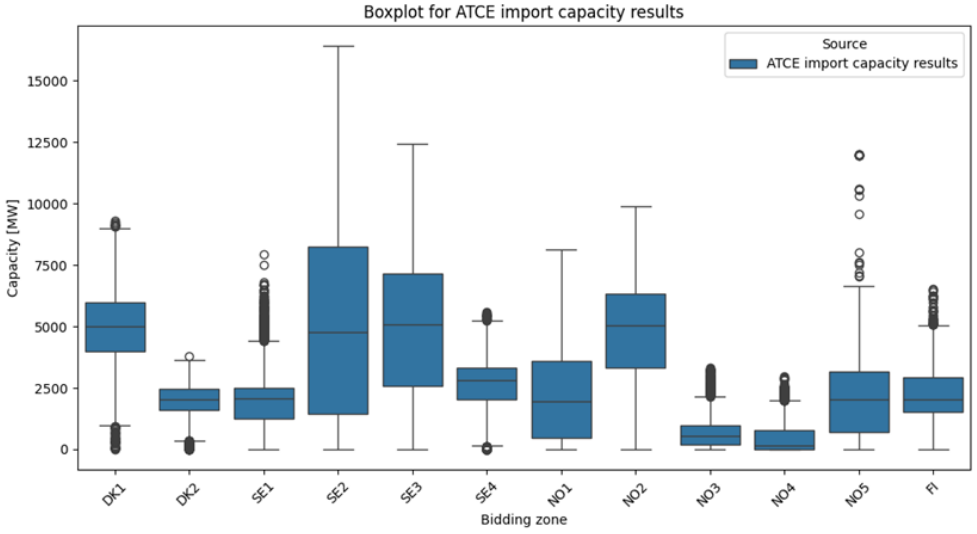

Figure 4 Boxplot for ATCE import capacity results using the PTDF 1 % relaxation

PTDF-relaxation 2 %

Figure 5 and Figure 6 show the given export and import intraday capacities using the 2 % PTDF

relaxation. Compared to the 1 % PTDF relaxation, the capacities are higher and only NO4 export capacity remains limited, at a median value of 262 MW.

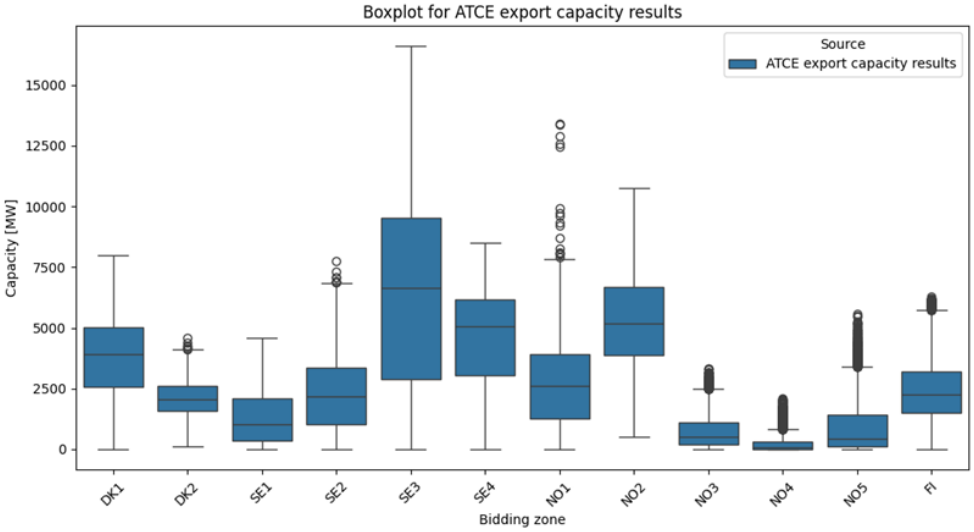

Figure 5 Boxplot for ATCE export capacity results using the PTDF 2 % relaxation

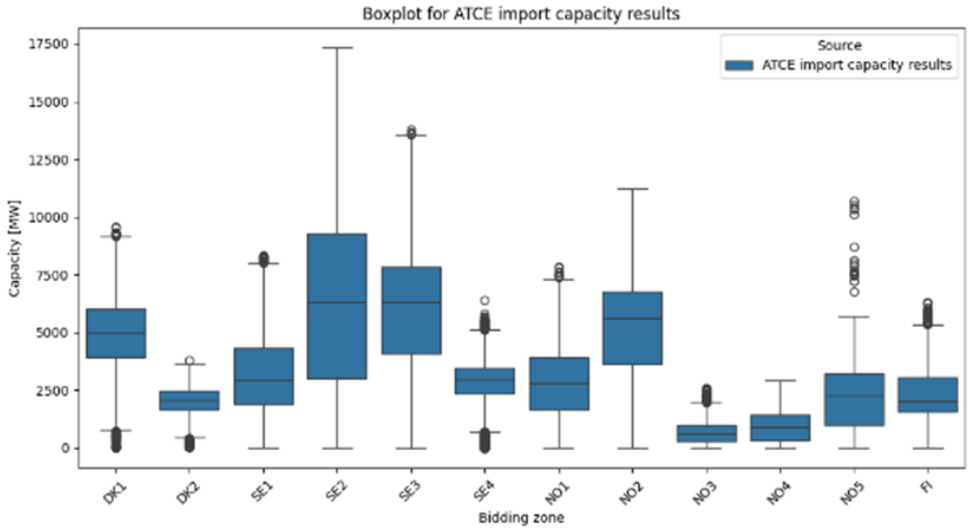

Figure 6 Boxplot for ATCE import capacity results using the PTDF 2 % relaxation

PTDF-relaxation 3 %

Finally, Figure 7 and Figure 8 show the given export and import intraday capacities using the 3 % PTDF relaxation. Compared to the 2 % PTDF relaxation, the capacities are even higher, but again, the export capacity in NO4 remains relatively limited at 280 MW. This is only a 20 MW increase on the NO4 border compared to the 2% PTDF relaxation.

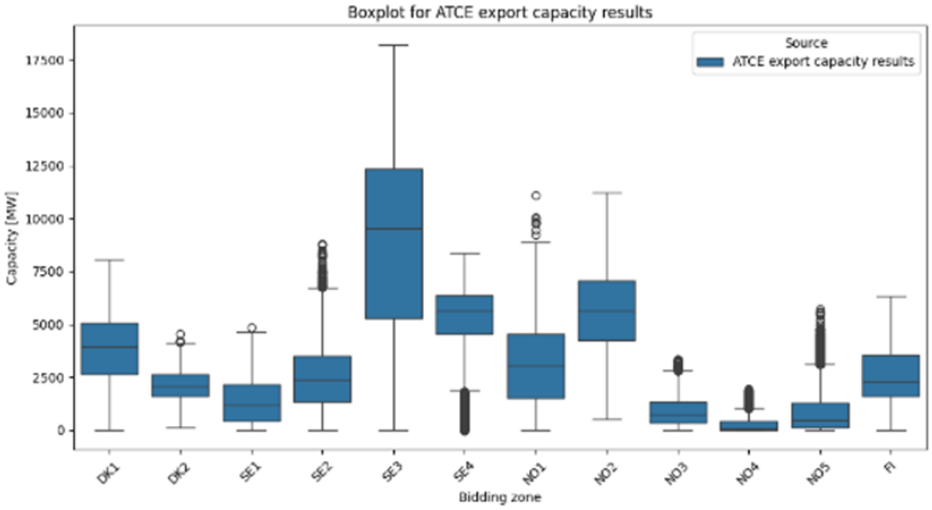

Figure 7 Boxplot for ATCE export capacity results using the PTDF 3 % relaxation

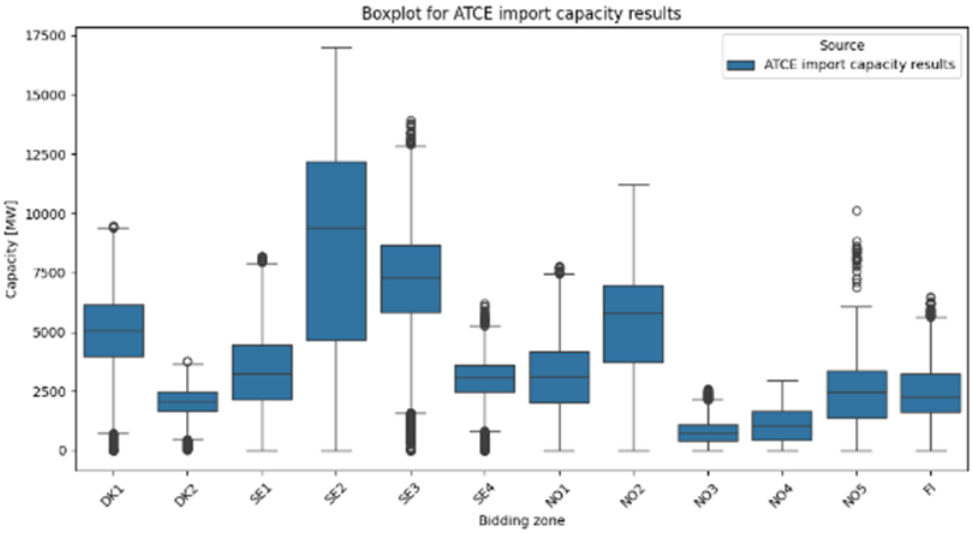

Figure 8 Boxplot for ATCE import capacity results using the PTDF 3 % relaxation

Lock-in on bidding zones

Table 1 shows the percentage of total hours per bidding zone where the cross-border intraday trading possibilities (i.e. sum of import and export capacity) are less than 100 MW at different relaxation settings. At 0 % PTDF relaxation, especially for NO3 and NO4 the trading possibilities remain very limited for a large share of the time but also NO5, SE2 and SE3 see quite a high share of hours with limited cross-border intraday capacity. When relaxation is loosened to a 1 % PTDF, there are significantly less hours with limited trading possibilities and only NO4 sees a relatively high share of hours with low capacity. At

a 2 % PTDF setting, there are only five bidding zones that have hours with less than 100 MW of cross-border intraday trading possibilities.

For these five bidding zones, the share of hours with small capacities is very low. NO4 has the highest number of 1.6 % of total hours where the trading possibilities are less than 100 MW. When PTDF relaxation is set to 3 %, there are only three bidding zones with less than 100 MW of trading possibilities. For all these three bidding zones the share of those low-capacity hours is very small, with NO4 being the highest at a 0.7 % share. Nevertheless, the difference from a 2% PTDF to a 3% PTDF relaxation is not very significant.

Table 1 Bidding zones where the ATCE trading possibilities are less than 100 MW (% of total hours) at different relaxation settings

Bidding zones where the ATCE trading possibilities are less than 100 MW (% of total hours)												
	SE1	**SE2**	**SE3**	**SE4**	**NO1**	**NO2**	**NO3**	**NO4**	**NO5**	**FI**	**DK1**	**DK2**
PTDF 0 %	1.8	7.7	2.7	0.2	0.1	0	18.6	45.6	5.8	0	0	0
PTDF 1 %	0.1	0.7	0.1	0	0.02	0	3.2	23.1	2.4	0	0	0
PTDF 2 %	0	0.03	0.6	0	0	0	0.9	1.6	0.6	0	0	0
PTDF 3 %	0	0	0	0	0	0	0.5	0.7	0.2	0	0	0

Lock-in on borders

Table 2 shows the percentage of time that each border experienced a lock-in situation, meaning that the available intraday capacity, i.e. the sum of capacities in both directions of a border, was less than 1 MW, when applying the PTDF-relaxation and RAM-relaxation parameters. It can be seen from this table that some borders were rarely affected by lock-ins, while others, such as SE4-SE_NB, DK1-DK1_CO and SWL, had relatively frequent lock-ins. This suggests that the relaxation parameters did not have a uniform impact on all borders and that the relaxation parameters were not sufficient to eliminate the risk of lock-ins completely. There was no difference in lock-in situations between the 2 % and 3 % relaxation settings, but if the relaxation is set to 1 %, slightly more lock-in situations occur.

Table 2 Lock-in situations on borders for the different PTDF-parameters. There are a few extra borders that are not included, as they had lock-ins less than 1% of the time. For NO4-SE1 and NO4-SE2, the values are higher for 1% PTDF than for 0% PTDF relaxation, which could possibly be explained by the optimizer finding an overall better solution but limits these two borders more

	DK1-DK2	DK1-SE3	FI-SE3	NO4-NO3	NO4-SE1	NO4-SE2	NO1-NO5	NO3-NO5	NO3-SE2
PTDF 0%	1.7	2	1	2.5	0	1.5	4.9	5.0	1.3
PTDF 1%	1.7	2	1	1.3	1.8	2	0	0	0
PTDF 2%	1.7	2	1	0	0	0	0	0	0
PTDF 3%	1.7	2	1	0	0	0	0	0	0

Potential overloads and security assessment

The higher the applied relaxation is, the more capacity is given to the intraday market. However, when applying larger relaxation, the higher is the risk for operational security. The first setup of relaxation was a PTDF-relaxation of 5 % during the first part of the EPR. However, that level of relaxation made it possible to severely overload several CNECs mainly in Norway and Sweden, the two most interconnected countries, in an operational insecure way. Hence, the TSOs agreed to apply another setup of relaxation with different PTDF- and RAM-relaxations, as described above. The goal was to reduce the possibility of overloads on the Norwegian and Swedish CNECs while maximizing the possible ID-capacities, taking into account the likelihood of flow directions and non-relevant loop-flows. The TSOs agreed that, with the chosen setup of a 2 % PTDF-relaxation and a 10 MW RAM-relaxation according to Table 3, the risk of overloads was acceptable and within the uncertainty of the D-2 capacity calculation.

Table 3 illustrates what the potential overloads could look like in week 5 in 2024 for the different PTDF relaxation values if trades would be in the likely market direction. This is defined as all possible trades from a low-price area to a high-price area. Thus, the numbers show the overload on CNECs if all available ATCE capacity from the lower price to the higher price area would be traded on. These types of trades are likely to occur. The RAM relaxation remains at 10 MW for all examples, as there was not much gain in capacity by increasing it further. In Table 3 we only include overloads larger than 10 MW, as the 10 MW RAM relaxation will always allow up to 10 MW of overload[3].

Without any PTDF relaxation, the number of potential overloads and the values for maximum and average overload is quite small and unproblematic. However, as shown above, the capacities are also quite limited. The number of potential overloads increase almost five-fold when using 1% PTDF relaxation, and the maximum potential overload would be 39 MW. This is still easily handled by the operators. For 2% PTDF relaxation, the number of potential overloads again increase, and the maximum and average potential overloads also increase significantly. An overload of 154 MW on a CNEC would be a challenge for the operators to handle, but it is assumed that not all the trades that lead to this overload would occur at the same time. Also, even in the case that it would occur, the operators should be able to handle this. There is also a substantial increase in potential overloads of more than 20 MW. Finally, using 3% PTDF relaxation, there are somewhat more cases of potential overloads, but the main challenge is the maximum overload level. An overload of 273 MW on a CNEC would pose a significant challenge for the operators, even if the realistic number is somewhat smaller. The average potential overload is also more than 100 MW, which was deemed to be infeasible by the operators. The number for this week is quite representative for other weeks as well. Thus, 2% PTDF relaxation was the highest level of risk all the TSO operators could accept.

[3] For 0% PTDF relaxation, one would expect a maximum of 10 MW overload. However, due to an incorrect flagging that occurs on the Skagerrak cable (NO2-DK1), one CNEC gets more than 10 MW overload. The reason is due to the HVDC losses not being part of the optimization; this happens for all PTDF relaxation values.

Table 3 Shows the number of overloads and maximum and average overload above 10 MW for week 5 in 2024, at different relaxation settings. The table also shows the number of overloads larger than 20 MW. The numbers are representative for other weeks as well.
*See footnote 3 for an explanation why there are overloads more than 10 MW for 0% PTDF relaxation.

	0 % PTDF & 10 MW RAM relaxation	1 % PTDF & 10 MW RAM relaxation	2 % PTDF & 10 MW RAM relaxation	3 % PTDF & 10 MW RAM relaxation
Number of overloads	36	157	606	706
Max overload*	17	39	154	273
Average overload*	15	15	63	112
Number of overloads >20 MW	0	20	487	623

TSO assessment on possible market effects

First and foremost, it is hard at the current stage to accurately assess the possible impact on the ID-trade with the ATCE-capacities. The DA market results from the NTC and the FB-method differ, meaning that we have two different starting points with different needs for additional ID-trade. Hence, a comparison of the actual ID trade from the NTC-method with the ATCE-capacities isn't an accurate method. It has not been possible to conduct a parallel run on the ID-continuous trade with the two different market outcomes and ID-capacities. Hence, any comparison between actual ID-trade with the new ATCE-capacities will be inaccurate. Moreover, one has to bear in mind that DA FB increases the utilization of the grid capacity, thus ceteris paribus, less capacity is available for ID.

With that said, if we assume that the ID-trade would have been the same with the FB-method and ATCE-capacities, then we can analyze if the ATCE would limit those trades or not. Table 4 shows that the ATCE is smaller than the corresponding value in the NTC-world, meaning that we will have cases where the ID-trade couldn't be met for the specific bidding zone. It is especially export that could be limited with the average excess trade around 150 MW for most borders. For import, the percentage of time where the ID-trade couldn't be met for the specific bidding zone, is quite small (around 1-4 %). If we assume that the entire ID-trade was needed to correct an imbalance (which is not necessarily the case) the TSO will need to prepare to handle the imbalance in real-time using the tools at their disposal. These tools are mentioned below. Note that the table covers the period of week 26, 2023 to week 12, 2024, which

includes cases where large power plants have tripped which would have been replaced by ID-trade made by the BRP.

Table 4 Shows the percentage of time the ID import and export trade was larger than the ATCE capacity, together with the mean excess volume for those hours (week 26, 2023 – week 12, 2024).

Bidding zone	Percentage of time ID export trade>ATCE export capacity [%]	Average excess ID export trade>ATCE export capacity [MW]	Percentage of time ID import trade>ATCE import capacity[%]	Average excess ID import trade>ATCE import capacity [MW]
DK1	2.5	365	0.6	417
DK2	0.4	338	0.4	182
SE1	14.0	113	0.7	116
SE2	7.8	161	4.0	183
SE3	7.7	331	2.1	275
SE4	1.9	152	1.6	197
NO1	1.1	149	2.66	147
NO2	0.06	337	3.0	156
NO3	4.4	73	3.5	76
NO4	28.3	24	4.1	37
NO5	10.9	100	1.4	69
FI	1.2	176	1.0	146

The TSOs acknowledge and agree that the capacities provided with ATCE are for some cases lower and more volatile than in the current NTC market. The reasons for lower capacities are primarily because more capacity has been allocated and utilized for the DA-market. Thus, there is less capacity remaining in the ID market without inducing overloads. Moreover, the ATCE also takes more flows into account (meaning that some unrealistic limitations have been applied). Lastly, the ATCE is also bound to follow the limitations in the entire Nordic grid, meaning that loop-flows between different bidding zones, that are not considered today, will be taken into account with the ATCE methodology. The result will be both more capacity on the DA-timeframe and more operational secure capacity for both the DA and ID-timeframe compared to what is possible with today's methods. Also, when comparing today's intraday trades with the ATCE capacities, there are some borders that regularly traded more than what the ATCE result would have allowed for. Specifically, SE1, NO4 and NO5 have quite limited export capacities with ATCE. However, these borders are usually exporting fully in the day-ahead timeframe and the day-ahead export increases in flow based compared to NTC. Therefore, these lower intraday capacities are somewhat expected. In terms of import, there are fewer bidding zones where the traded volumes in today's market are higher than the ATCE capacities.

This reduction of ID capacity can cause market participants to struggle with trading themselves into balance in the intraday market. Several cases have been observed where the ATCE capacities are too low to provide sufficient trading possibilities in case of a trip on a large generation unit. However, as stated above, higher DA capacities will probably reduce the need for ID trades to a certain degree, and the ATCE capacities should thus still provide an acceptable level of capacity in most cases.

The impact on the balancing timeframe

The Nordic balancing model (NBM) project is planned to go live shortly after the DA flow-based market coupling and will, among other things, automate the manual frequency restoration reserves (mFRR) and handle the bottlenecks in the system. This is a necessary change to relieve the operators from manually activating reserve bids, which will be more demanding going forwards. Having sufficient capacity to meet the balancing need will probably be even more important going forward, as it is an automatic algorithm that will handle the imbalances. To meet the balancing needs, the TSOs rely on the total sum of cross-border capacity between bidding zones and the internal balancing capacity within a bidding zone.

The TSOs rely on the excess capacity after ID trades to be used in the balancing market. As the ID cross-border capacities are lower with ATCE, TSOs also expect that the capacity to be used for balancing will be reduced. This may result in higher balancing prices in importing areas and may also introduce higher capacity procurement costs. However, there might also, in some situations, be insufficient volumes and capacity to ensure balance at all. If this happens, the TSOs have two possible mitigation measures for cross-border capacities; they could increase the capacity after the ID gate closure and manage the operational risks in real-time, or they could reserve more capacity for balancing before the DA timeframe. If there are balancing issues inside a bidding zone, TSOs could procure more balancing capacity within bidding zones for the balancing timeframe, in accordance with the FRR dimensioning methodology.

As flow-based improves the representation of the grid, there will likely be lower local activations to mitigate congestions, which reduces the reserve needs for handling local congestions. This will have a positive impact for balancing, but it is difficult to state by how much. Overall, the TSOs will ensure operational security following the FRR dimensioning methodology. When the intraday capacities are lower than the required trading volumes, not all market participants may be able to trade themselves into balance in the intraday market. If this happens, the TSOs and NBM will take over, and use the balancing market to ensure balance in real-time.

Planned and potential measures

The CCM project is continuously working on analyzing and improving the ATCE methodology. Due to limitations on larger IT-changes before go-live, there will be no changes to the tooling before go-live.

However, several improvement measures have already been identified, that will be implemented after go-live. First and foremost, the Nordic regional coordination center (NRCC) is working on a new version of the ATCE tool that will be able to handle the transition to the 15-minutes imbalance settlement period in the intraday market. This tool will also be more flexible, so it is easier to implement future improvements. The current plan is that this tool should be ready in January 2025.

There are currently several improvement measures that will be added to this tool. First, it will change from an NTC optimization to an ATC optimization. This will move the starting point of the optimizer from zero to the market point and will ensure more consistent results. From the initial testing, the capacities increase somewhat overall, but more analysis will be done in the next months. Second, the current implementation prioritizes HVDC cables with virtual bidding zones when running the optimization, because there are seemingly two borders (X-X_VBZ and X_VBZ-Y) for each direction. The new ATCE tool will remove this double counting from the optimization, so no borders will be prioritized over others. Finally, the new tool will also remove NO4-FI and Baltic cable from the optimization, as they are not part of the intraday market. The current tool includes them in the optimization, but they are set to zero afterwards. Not including them in the optimization allows that capacity to be given somewhere else.

The CCM project is also looking at other options to further improve the ATCE results. One of these is to provide the optimization function with a constraint on realistic net positions. Doing so hinders the ATCE result in giving high capacity on borders where it is unrealistic that there is enough supply or demand to match the capacity. The TSOs will also work on updating the ID ATC gate-opening capacities during the ID timeframe, to adjust the capacities where and when possible. This requires updated CGMs and a re-assessment of the FB domains, as well as reruns of the ATCE.

Overall, there are several improvement measures planned for, and more being analyzed for future potential implementation. The CCM project believes that these measures will provide higher and more consistent intraday capacities. These improvements will be applied in accordance with the approved DA/ID CCM article 20 paragraph 3 - 5.

ANNEX 2: Arbitrage[4] possibilities

Background (the issue)

The NRA has asked the NRCC and the TSO the following question:

"The combination of including CNECs with small PDTFs in the day-ahead capacity calculation and relaxations in ATCE creates new possibilities for arbitrage. On the other hand, not relaxing the ATC domain would further reduce the ID capacities made available to the market. The Nordic NRAs acknowledge that the transitional solution with use of ATCE in the intraday capacity calculation entails a need to strike a balance between operational security and sufficient ID capacities. ***The TSOs should therefore thoroughly investigate the necessary level of relaxations in ATCE and minimize the consequences of these new arbitrage opportunities."***

This Annex answers this request by going through the case of arbitrage and applied relaxation parameters. First of all, the ATCE methodology, with a relaxation on the FB parameters, implies that some additional capacity will be offered to the intraday market that was not available for the day-ahead market. This introduces some possibilities for arbitrage in intraday. The reason for these relaxations, on both PTDFs and RAM, is, as the NRAs state, to find the right balance between operational security and sufficient ID capacities. The assessment is described in Annex 1. These relaxations increase the ID-capacities while keeping the possible operational risk for additional overloads on relevant constraints to a feasible level. Yet, while these relaxations allow for more capacity to be allocated to the ID-market compared to the DA-market, it also opens up the possibility of arbitrage. This Annex answers the consequence of arbitrage possibilities as a result of the chosen relaxation settings.

TSO assessment on arbitrage possibilities

If – for whatever reason – intraday capacity is released from a low-priced to a high-priced bidding zone, and if this situation can be foreseen by market participants, an arbitrage opportunity arises. The TSOs have analyzed the amount of arbitrage possibilities with the decided relaxation parameters during the "re-run period", covering 26th of June 2023 to 24th of March 2024, and gained the following results.

Figure 9 shows the percentage of time where arbitrage (meaning both a positive price-spread and positive ATC) may arise for different borders. The figure shows that the possibilities vary between the borders and may arise around 5-15 % of the time for most of the borders. NO2-DK1[5], NO5-NO2, SE2-SE1, SE3-SE2, SE4-SE3 and SE1-FI have arbitrage possibilities for 25 % of the time or more.

[4] Wikipedia: it is the possibility of a risk-free profit after transaction costs. For example, an arbitrage opportunity is present when there is the possibility to instantaneously buy something for a low price and sell it for a higher price. https://en.wikipedia.org/wiki/Arbitrage

[5] The percentage of NO2-DK1 is high due to implicit net loss in the DA timeframe in FB. However, this occurs in the NTC as well.

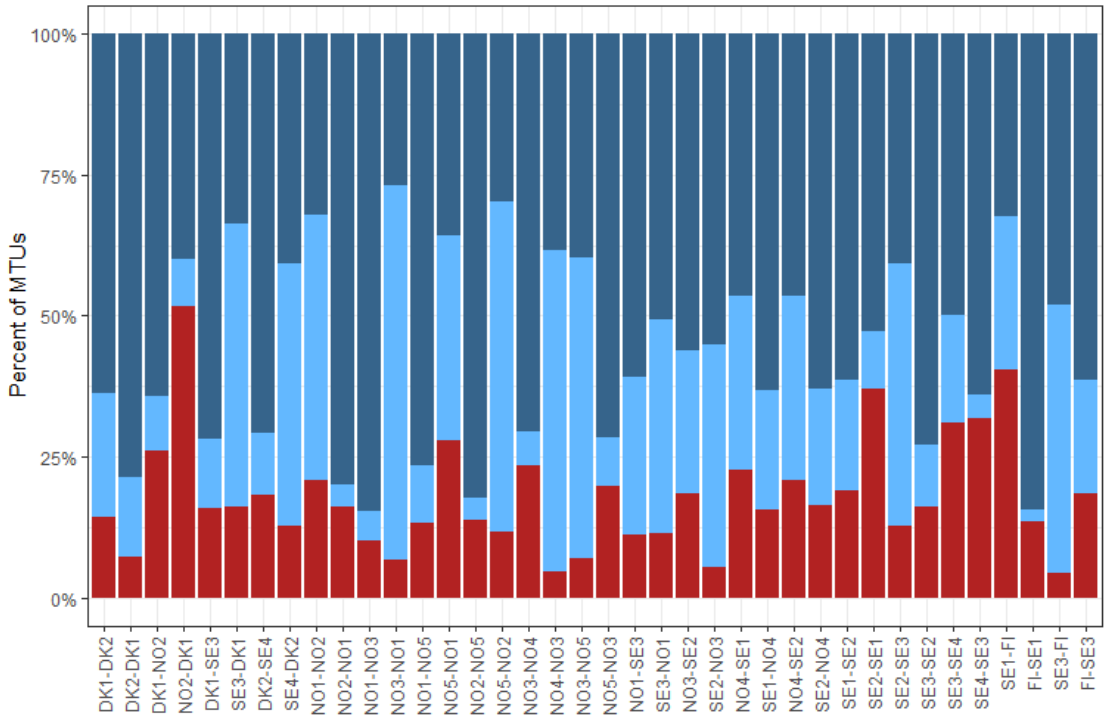

Figure 9: Percentage of MTUs with arbitrage possibilities Dark blue: No positive price spread = No arbitrage. Light blue: Positive price spread but no ATC = No arbitrage. Red: Positive price spread and ATC = arbitrage possibility. In this graph, the dash sign "-", in this context/report, is directional, e.g. NO3-NO4 means from NO3 to NO4.

The total arbitrage possibility is decided by the provided capacity and the positive price spread between the adjacent bidding zones. The TSOs have control over the provided capacity and Figure 10 shows the positive ATC for different borders. The ATCE for DK1-NO2, NO5-NO1 and SE1-FI is small and below 5000 MW for a total period of 6529 MTUs. For SE2-SE1, SE3-SE2 and SE4-SE3 the positive ATCE is higher.

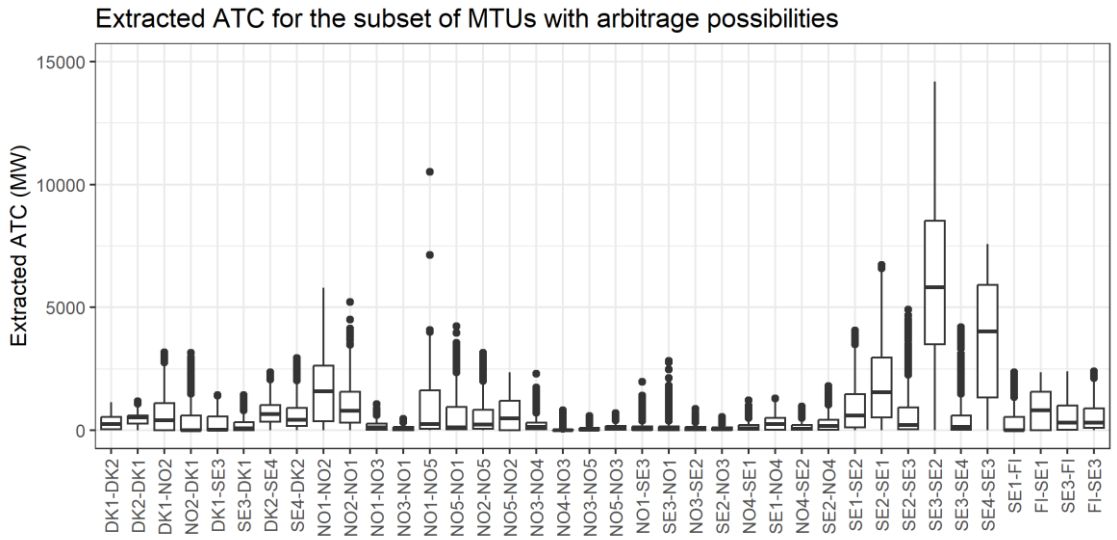

Figure 10 The extracted ATC for the subset of MTUs with arbitrage possibilities

The market participant's ability to respond to arbitrage possibilities depends on their capability to predict the arbitrage situation. The impact is also determined by how easy it would be to predict arbitrage situations in order to utilize these in a structured way. Figure 11 shows the possible range for the Swedish corridors, which indicates that the arbitrage possibility varies in a random way which would be hard to predict for market participants.

Predictability

Easy-to-predict arbitrage situations:

- Market participants have incentives to change their behavior already in the day-ahead market.
- Can be exploited by market participants irrespectively of their intent to trade for underlying consumption or production.

Hard-to-predict arbitrage situations

- Less likely to have an impact on the day-ahead market.
- More difficult to exploit for market participants who do not have actual (and flexible) resources in the bidding zones.

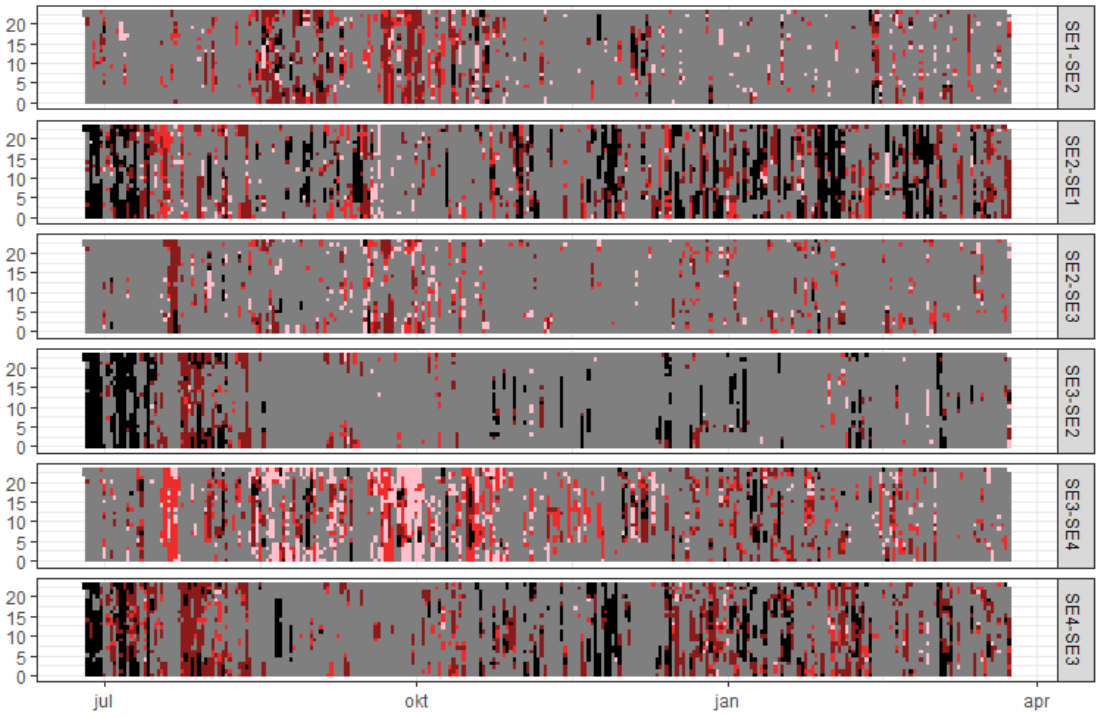

Figure 11 Heat map showing the arbitrage possibilities for the Swedish corridors. The light to dark dots mark the possible arbitrage situations as a share of gain. The light red dots mark a small gain and the darker red dots mark a higher gain (and black marks the highest gain). The grey area shows no arbitrage possibilities

In general, from an economic-efficiency point of view, arbitrage should not lead to any (significant) socio-economic welfare loss. As arbitrage occurs as a result of relaxations, there will be "virtual capacities" given to the market. The market participants will trade using these capacities, which will move the market point away from the welfare optimum in the day-ahead market. If these trades result in overloads on CNECs, the TSOs will use the necessary tools to avoid that the CNEC is overloaded. This may bring the market point back to the optimum. Thus, there has been no welfare loss in this process, yet TSOs cannot rule out that, for whatever reason, a distortion of merit order might happen (compared to a least-cost generation from the DA market).

Moreover, the introduction of Intraday Auctions (IDAs) may take away some of the arbitrage gain from market players as they may materialize as congestion rent to TSOs. Please note that the first thing that happens at ID gate opening, is the running of the first IDA. If there, at the point of departure, is a DA congestion and thus DA price spread, the relaxation by 10 MW may not result in an arbitrage gain of ΔID price multiplied by 10MW, but as a congestion rent to TSOs. For instance, if one or more market player(s) submit an ID purchase bid of 20€ in SE2 and a sales bid in SE1 of 30€, this may cause a congestion and thus a congestion rent to TSOs; hence nothing is gained by conducting an arbitrage game.

However, we cannot be sure that the potential arbitrage gain will materialize as congestion rent to TSOs, it depends on the competitive pressure on the exporting side of the BZ-border. If a market player can impact the price he/she may not submit a purchase bid of 20€ in SE2 but, say 29€, which means the 9€ out the 10€ in congestion rent is obtained by the market players. We do however assess that the introduction of IDAs will remedy potential negative efficiency consequences of RAM relaxations.

Planned and potential measures

The TSOs deem the arbitrage possibility small and hard to predict for market participants, and have no planned measures before go-live. However, the TSOs plan to assess the situation continuously in close cooperation with the NRAs, i.e. to analyze the market impact which relates to arbitrage. At the moment, the gain of increasing the capacity in a balanced way between operational security and sufficiency for the ID-market is larger than the possible negative effects in the form of arbitrage. Furthermore, the chosen relaxation parameters have reduced the capacities compared with the former (i.e. 5 % PTDF) relaxation and hence reduced the arbitrage possibilities.